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Water status monitoring in almond and walnut orchards using random forest and remote sensing

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Water status in almond and walnut orchards is critical in optimizing irrigation management practices since it affects productivity, nut quality, and composition. Water status is frequently determined by the midday stem water potential (SWP) of almond and walnut orchards. Using SWP, allows for determination of the water status of almond and walnut trees, as well as to compare stress between days. SWP measurements are collected on a tree-by-tree basis and do not provide information on spatial variability or the comparison of different time periods because the recorded value is affected by both soil water content and the weather conditions on the day of the measurement, which makes comparisons between different time periods impracticable unless SWP readings are normalized by a baseline (non -water stressed tree under similar environmental conditions). The utilization of a very high-resolution manned and unmanned aerial vehicles equipped with multispectral cameras is being used to record the variability of different spectral features from the plant to the field-scale.

With this research, we aimed to construct a data-driven model based on the Random Forest (RF) ensemble technique to predict SWP spatial variability in drip and sprinkler irrigated almond and walnut orchards in the Central Valley of California, USA. For the training of the RF model, SWP data from three crop seasons from 2019 to 2021 were used along with Landsat-derived evaporation fraction, normalized vegetation index, soil water content from neutron probe, meteorological parameters, and soil properties as covariates. The results demonstrate that the trained model was capable of predicting the SWP at higher spatial resolutions when aerial imagery data were used in conjunction with the trained model. The R^2 values for training and validation for almond and walnut orchards were 0.92 and 0.84, respectively. Using the results of the comparison between the pressure chamber measurements and the RF model predictions, we were able to estimate SWP with root mean square errors (RMSE) of 2 and 1.2 bars, mean absolute errors (MAE) of 1.2 and 0.96 bars, and mean bias of 0.62 and 0.48 bars in almond and walnut orchards, respectively. These results demonstrate the capabilities of a machine learning-based RF algorithm for predicting the SWP at higher spatial resolutions by using satellite, aerial imagery, and other meteorological variables as covariates. Spatial maps of SWP can be used by growers to optimize precision irrigation management in orchards characterized by water induced spatial variability.